Robotics in Undersea Warfare

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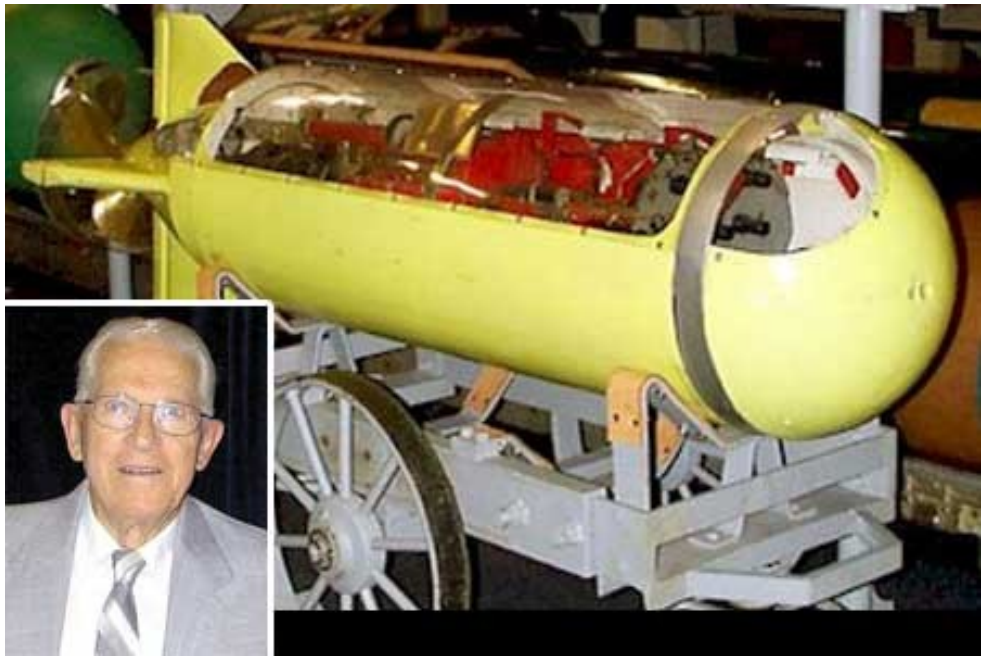
FIDO – Mk-24 “Mine”



Nomenclature

- **Unmanned Underwater Vehicle (UUV)**: Self propelled unmanned submersible
  - **Remotely Operated Vehicle (ROV)**: Tethered UUV controlled from a remote location.
  - **Autonomous Undersea Vehicle (AUV)**: Untethered UUV operating with no or very limited operator control.
- In this briefing torpedoes and towed submersibles are not considered UUVs

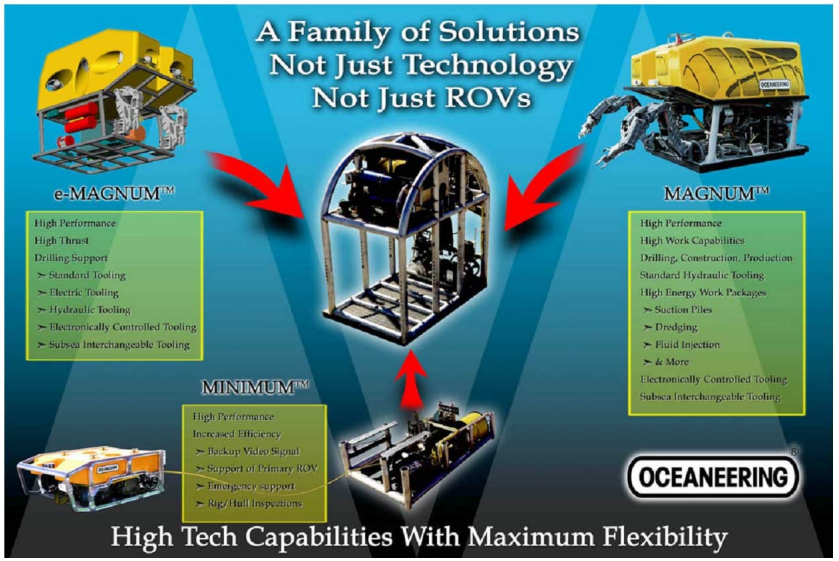
Undersea Environment (1)

- The ocean is dense and opaque
- High pressures in the ocean depths increase UUV complexity and cost
- Speeds are slow (a few knots), power required for propulsion is high, and oxygen is not readily available
  - However lift (buoyancy) is easy to achieve
- Sensor ranges are very limited:
  - Optics: at most 200-300 m but often less (high power lights required)
  - Active sonar: 100-300 m for imaging systems
  - Electromagnetics: RF energy not useable underwater; EM detection (near DC) is effective from a few meters to a few hundred meters
  - GPS is available at the surface only

Undersea Environment (2)

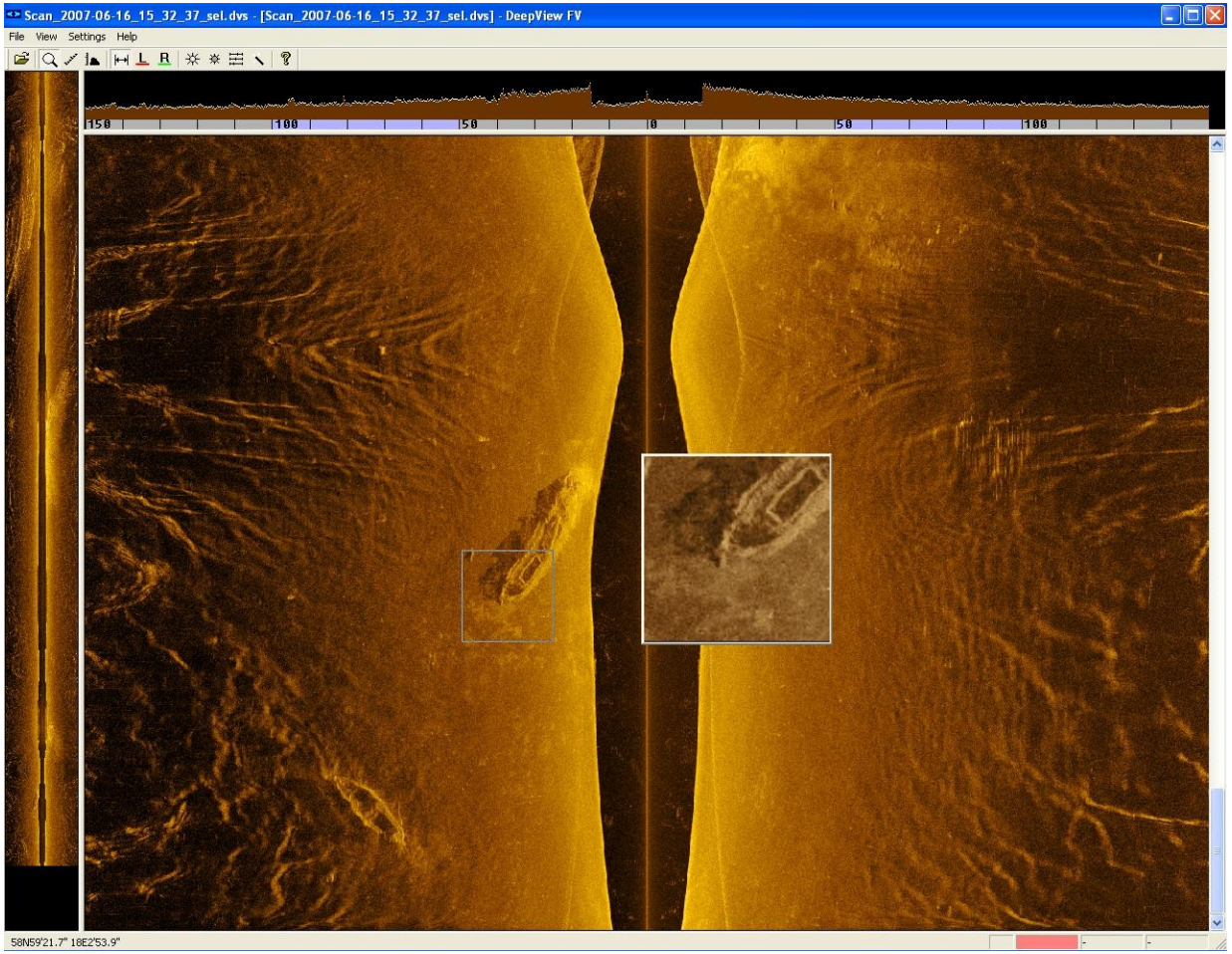
- Communications are very difficult
  - RF energy does not penetrate the water at communications frequencies (UUVs come to the surface to communicate to shore)
  - Acoustic signals have limited bandwidth (a few KHz) and propagate to short ranges (a few km)
- Complex autonomy is much more difficult than for atmospheric robots
- Deployment and recovery of UUVs often requires a sizeable shipboard equipment installation and a detachment of experienced personnel

Remotely Operated Vehicles (ROVs)

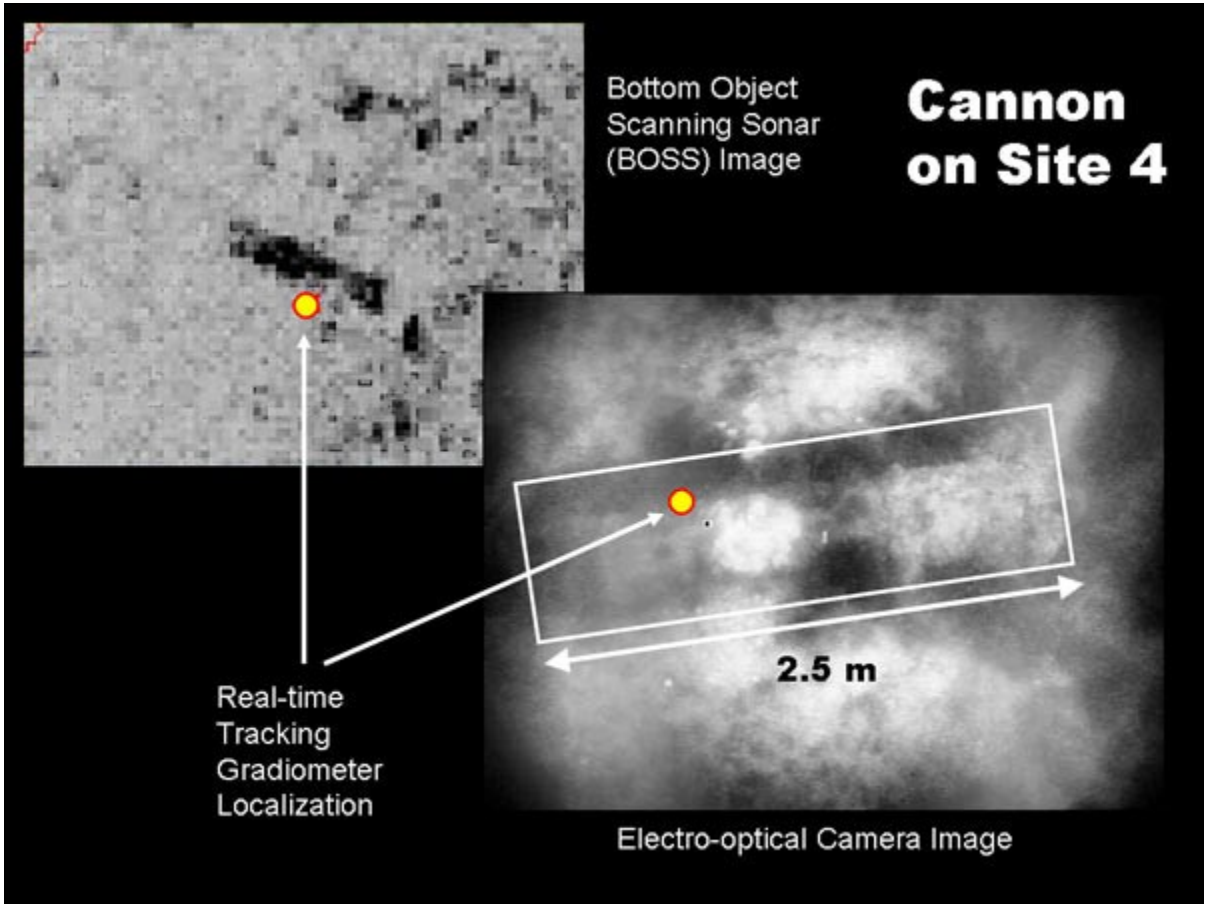


Hugin AUV

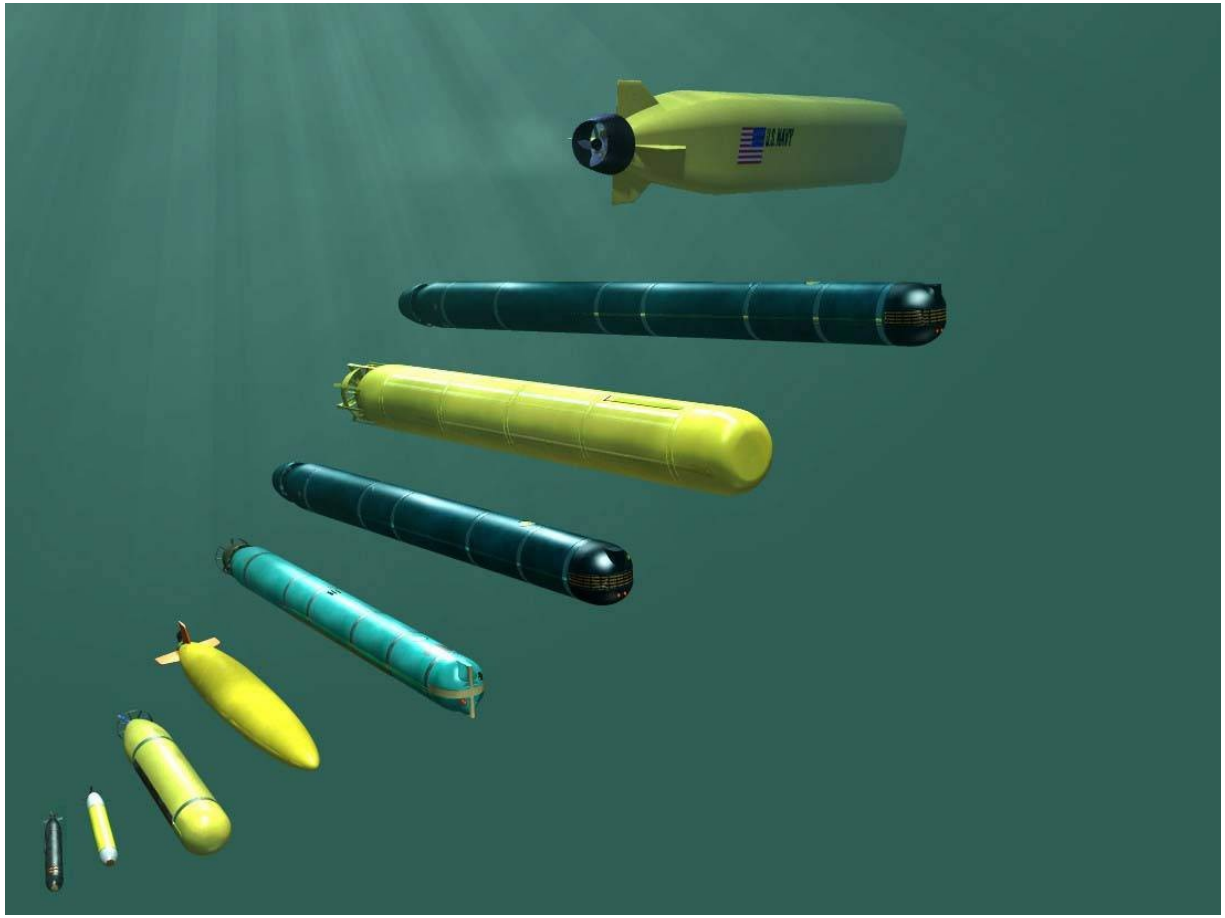
Imaging Sonar



Bottom Sensing



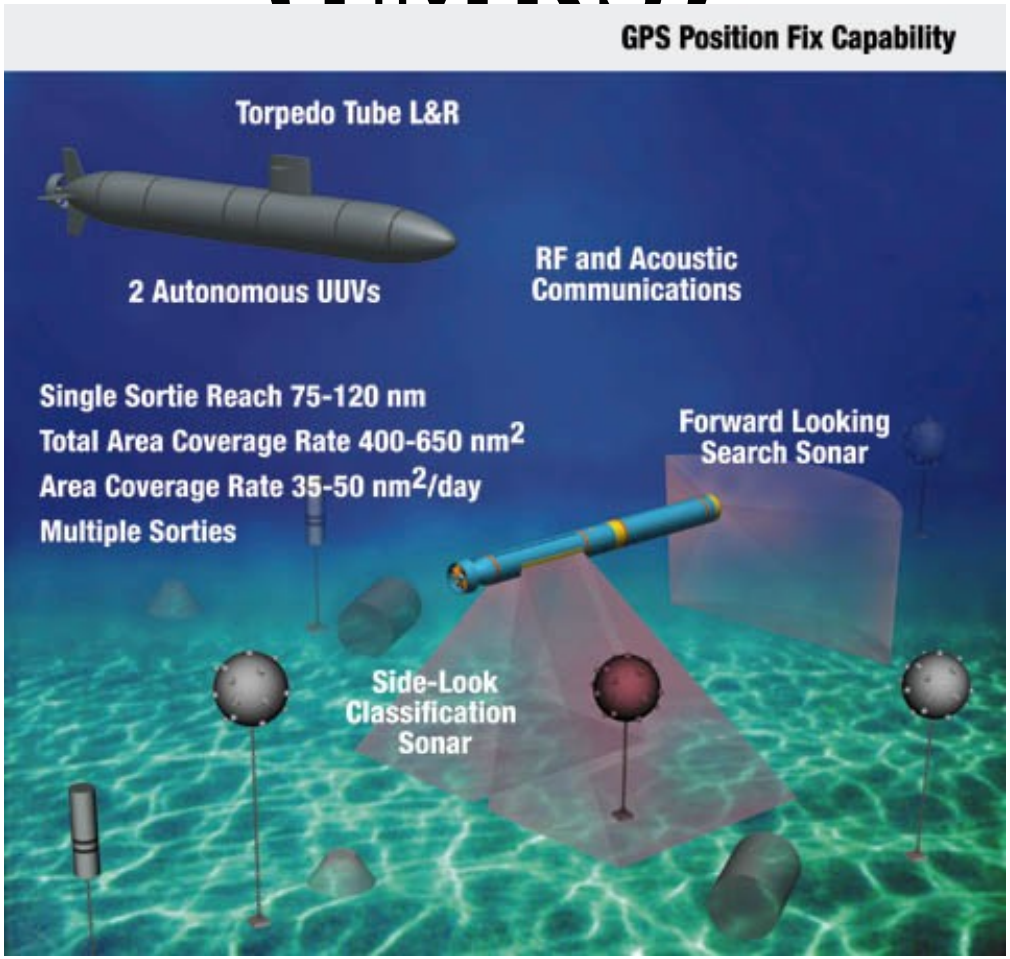
Navy Autonomous Undersea Vehicles (AUVs)



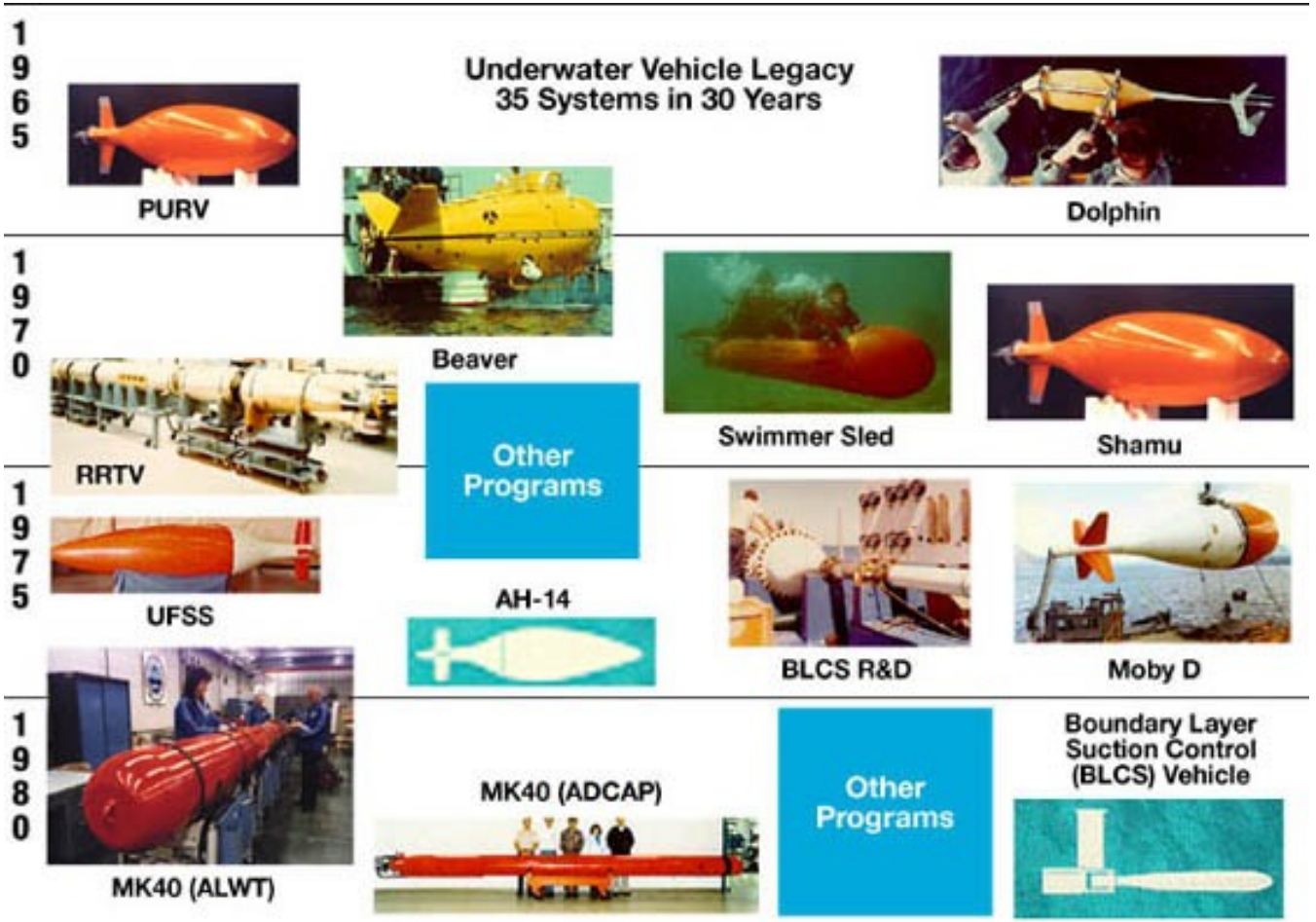
REMUS UUV


Navigation Transponders
Four small, lightweight transponders are supplied as reference beacons for the vehicle during operation. The transponders are preset to listen for a specific signal, which is transmitted by the vehicle, and then immediately reply. The vehicle may then easily compute the slant range to the transponder.
Acoustic Doppler Current Profiler (ADCP)/Doppler Velocity Log (DVL)
The specially designed Teledyne RD Instruments ADCP/DVL can be configured to include both downward and upward looking transducers, allowing for bi-directional current profiling, 3-D bottom track, altitude measurement and highly accurate dead reckoning navigation input. The altitude measurement, when coupled with the vehicle's position and depth, also provides seafloor bathymetry.
Conductivity and Temperature
The vehicle is equipped with a multi-parameter sensor sonde, which includes temperature and conductivity. Temperature information is stored in the REMUS 100's hard drive for plotting a profile of the water temperature in the search area. Conductivity and temperature inputs are used to accurately determine the speed of sound in water, which is used to increase navigational accuracy.
Side Scan Sonar
Side scan sonar designed specifically for the demanding AUV environment. The compact, light weight design incorporates the same proven technology found in traditional towed configurations.
Chemical Light Bracket
For night time operation.
Operation Speed
Programmable to operate at speeds up to 5 knots.
REMUS 100 Vehicle
100 Meter Depth Rating.
HYDROID
REMUS
Magnetic On/Off Switch
Navigation
The REMUS 100 navigates during a mission using three methods: Long Baseline (LBL), Dead Reckoning (DR) and Ultra-Short Baseline (USBL). The on-board computer automatically determines the preferred method, and can vary it through the mission.
Power/Data Interface Module
This module serves as an external power supply to recharge the Li-Ion batteries and to preserve the batteries when conducting on shore testing. It also provides a high-speed communications link to the vehicle, allowing data to be downloaded to one or more computers.
Acoustic Transducer and Cable
Portable low-drag transducer transmits and receives wideband signals from the vehicle and transponders to the Ranger unit.
REMUS Ranger
The REMUS 100 vehicle carries an emergency transponder; completely independent of the vehicle's other systems that may be interrogated at any time. The Ranger is a small, waterproof deck unit, designed to give the operator the ability to monitor the vehicles progress, via this transponder while the mission is underway. The Ranger consists of a highly portable deck unit connected to a small, towed transducer. The front panel display indicates the real-time range to the vehicle in meters and/or is used to send selected commands such as "abort mission" or "come home" to the vehicle during operation.
Ruggedized Laptop Computer
Includes intuitive graphical user interface designed for simple pre-launch checkout, mission planning, and data reporting.
HYDROID

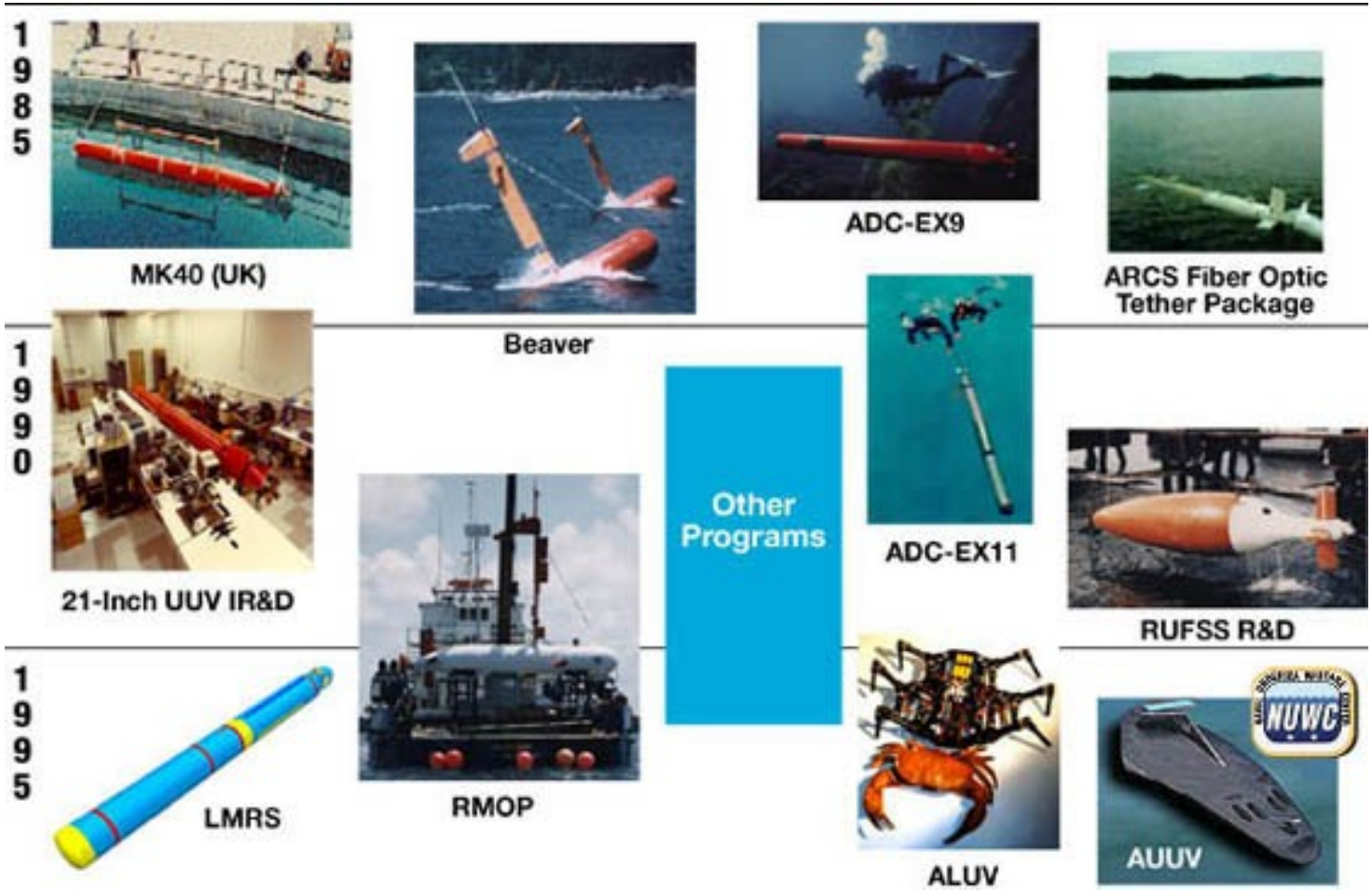
Long Term Mine Reconnaissance System (LMRS)



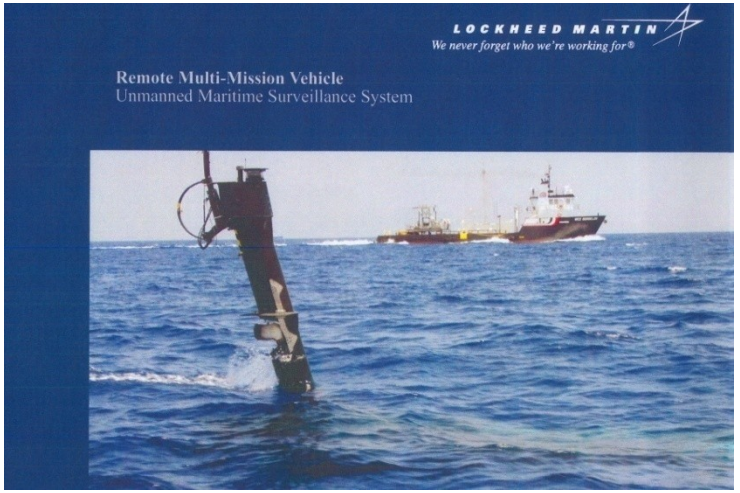
Boeing Undersea Vehicle History (1)

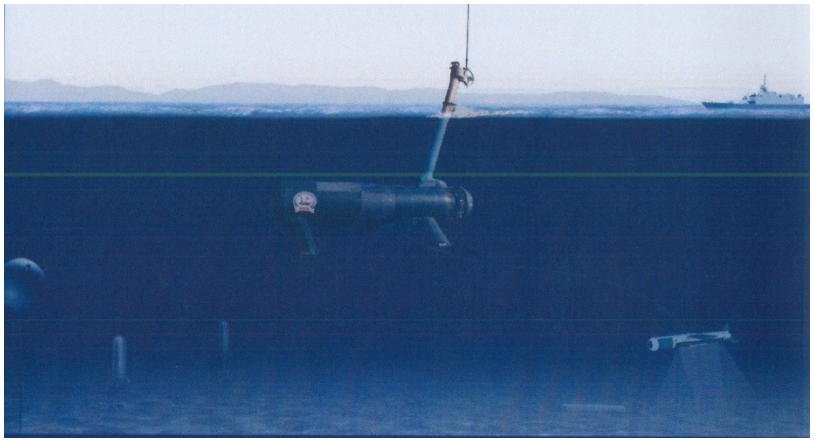


Boeing Undersea Vehicle History (2)



Remote Minehunting System (RMS)





Navy UUV Master Plan

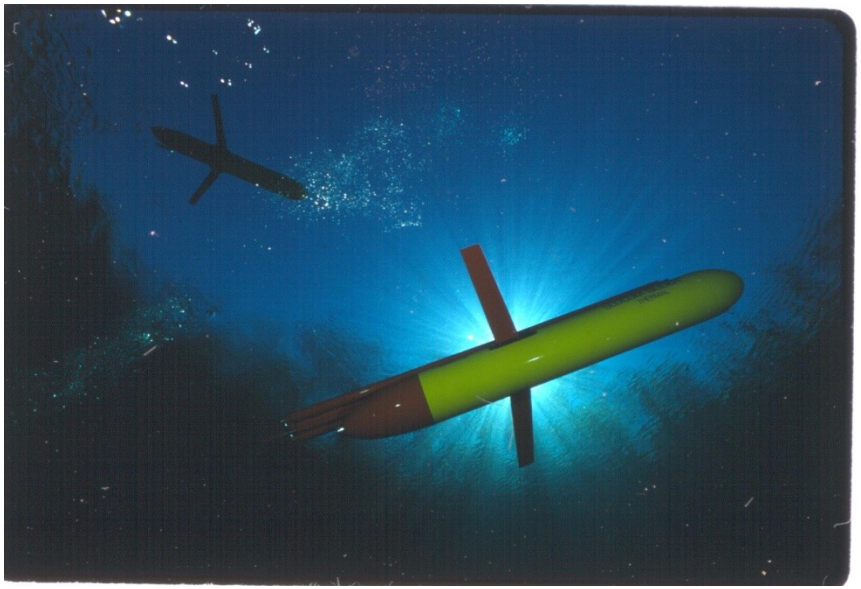
- First published in 2000 and updated in 2004
- Prioritized capabilities needed:
  - Intelligence, Surveillance, and reconnaissance
  - Mine Countermeasures
  - Anti-Submarine Warfare (ASW)
  - Inspection/Identification
  - Oceanography
  - Communication/Navigation Network Node
  - Payload Delivery
  - Information Operations
  - Time Critical Strike

Navy UUV Master Plan

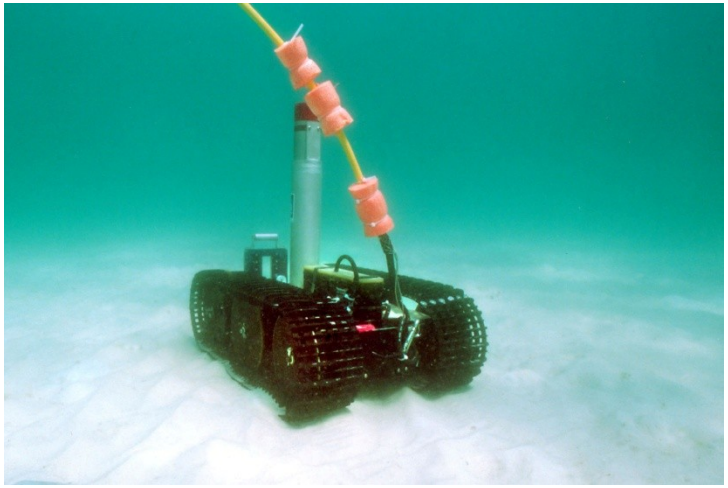
- Programmatic recommendations:
  - Develop four UUV classes
    - Man portable (<100lbs)
    - Light Weight (~500 lbs)
    - Heavy Weight (~3000 lbs)
    - Large (~20,000 lbs)
  - Develop standards and implement modularity
  - Establish a balanced UUV technology program
  - Increase experimentation in UUV technology
  - Coordinate with other unmanned vehicle programs
  - Field systems in the fleet

UUV Research

Glider AUVs



Research Concepts



Summary

- The US Navy has earnest aspirations for the future of UUVs
- There is no major funding for UUVs outside of S&T, oceanography, and limited bottom surveillance
- Commercial interests are driving UUV technologies
- The complexity of the undersea environment poses a major impediment to more rapid development